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Office type, performance and well-being

A study of how personality and work tasks interact with contemporary office environments and ways of working

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To my family

Abstract

Today, many organisations are adopting offices that have an open design with or without flexible seating. While advocates of open-plan offices propose that these office types lead to cost savings and aid inter and intra-team communication, opponents argue that these office types are associated with decreased performance and worsened health among employees. This thesis investigates how the type of office (cell offices, shared room offices, small open-plan offices, medium-sized open plan offices, large open-plan offices and flex offices) influences employee health and performance, and whether this is different for different personalities and jobs with different concentration demands. Data were gathered by means of surveys and cognitive tests from five organisations with different office types. In Study I (N=1241), the aim was to investigate the main effect of office type on indicators of health and performance and the interaction effect of office type with the need to concentrate in order to carry out work tasks. Office type alone was associated with distraction and cognitive stress in such a way that cell offices were associated with fewest problems, followed by flex offices, while open-plan offices were associated with most problems. While employees in open-plan offices and employees in flex offices reported more problems as the need for concentration increased, employees in cell offices reported the same level of problems regardless of the need of concentration. Study II (N=527) investigated how performance on a memory test was affected during normal working conditions as compared to a quiet baseline. There was a negative dose-response relationship between the size of the open-plan office environment and the drop in word recall during the normal working condition. However, Study II also showed that individuals working in cell offices had as high a drop in performance during normal working conditions as did those working in large open-plan office environments. Study III (N=1133–1171) focused on the interaction effect between office type and personality. The personality trait agreeableness interacted with office type on the outcome variables distraction and job satisfaction. Specifically, Study III may indicate that as offices get more open and flexible, agreeable people will report more problems. In conclusion, the

studies in the present thesis have implications for practice and suggest that office type impacts on employee health and performance, while concentration demands of the job and agreeableness moderate the effects. Although employees report higher level of distraction in open-plan office environments, when performance on a demanding task is measured, cell offices are not as favourable during normal working conditions as self-reported data usually indicate. Organisations should also be aware that, among open-plan offices, small open-plan offices are associated with fewer problems.

Keywords: Office type, open-plan office, flex office, cell office, performance, job satisfaction, distraction, self-rated health, well-being, cognitive stress, exhaustion, individual differences, personality, concentration, stimulus screening ability, memory.

Sammanfattning

Kontorslandskap med eller utan fasta arbetsstationer förekommer idag i många organisationer. Förespråkare för kontorslandskap hänvisar till kostnadsbesparing samt förbättrade förutsättningar för kommunikation, medan motståndare hävdar att kontorslandskap leder till försämrad prestation och hälsa bland medarbetarna. Denna avhandling undersöker om kontorstyp påverkar de anställdas hälsa och prestation, samt om effekten av kontorstyp varierar beroende på de anställdas personlighet och typ av arbetsuppgifter. Data i form av enkätsvar och prestation på kognitiva tester samlades in från fem organisationer med olika typer av kontorslösningar (cellkontor, delade kontorsrum, små kontorslandskap, mellanstora kontorslandskap, stora kontorslandskap och flexkontor). I studie I (N = 1241) var syftet att undersöka huvudeffekten av kontorstyp på indikatorer för hälsa och prestation samt om effekten är beroende av koncentrationskraven i arbetet. Kontorstyp visade samband med distraktion och kognitiv stress på så sätt att medarbetare i cellkontor uppgav minst problem, följt av de i flexkontor, medan kontorslandskap var förknippade med mer problem. Vidare rapporterade anställda som hade arbetsuppgifter som krävde koncentration mer problem i kontorslandskap och flexkontor, medan anställda i cellkontor, oavsett arbetets krav, rapporterade lika mycket problem. I studie II (N = 527) undersöktes hur prestation på ett minnestest påverkades under normala arbetsförhållanden jämfört med en tyst referensmätning i olika kontorstyper. Det fanns ett negativt dos-responssamband mellan storleken på kontorslandskapet och hur många procent sämre medarbetare presterade under normala arbetsförhållanden. Men Studie II visade också att personer som arbetar i cellkontor hade ett lika högt bortfall i prestation under normala arbetsförhållanden som de som arbetade i stora kontorslandskap. I studie III (N = 1133-1171) låg fokus på interaktionseffekten mellan kontorstyp och personlighet. Vänlighet var den enda personlighetsvariabeln som interagerade med kontorstyp på utfallsvariablerna distraktion och arbetstillfredsställelse. Mer specifikt visade Studie III att när kontoret blir mer öppet och flexibelt, så rapporterar människor som skattar sig högt på personlighetsvariabeln vänlighet fler problem. Resultaten i avhandlingen

kan få flera praktiska implikationer då den visar att kontorstyp påverkar medarbetarnas hälsa och prestation, medan koncentrationskrävande arbetsuppgifter och vänlighet modererar effekterna. Vidare visar avhandlingen att även om anställda rapporterar mindre distraktion i cellkontor jämfört med i kontorslandskap, behöver inte cellkontor vara lika gynnsamma som självskattade mått visar när prestationen mäts med objektiva mått under normala arbetsförutsättningar, i det här fallet ett minnestest. Slutligen bör organisationer även vara medvetna om att avhandlingen visar en viss tendens att små kontorslandskap är förknippade med mindre problem än stora.

Sökord: Kontorstyp, kontorslandskap, flexkontor, cellkontor, produktivitet, arbetstillfredsställelse, distraktion, självskattat hälsa, trivsel, kognitiv stress, utmattning, individuella skillnader, personlighet, koncentration, arbetsminne.

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Aram Seddigh
Stockholm, July 2015

List of publications

This thesis is based on the following studies:

I Seddigh, A., Berntson, E., Bodin Danielson, C., & Westerlund, H. (2014). Concentration requirements modify the effect of office type on indicators of health and performance. *Journal of Environmental Psychology, 38*, 167–174. doi: 10.1016/j.jenvp.2014.01.009. Reprinted with permission from Elsevier.

II Seddigh, A., Stenfors, C., Berntsson, E., Bååth, R., Sikström, S., & Westerlund, H. (2015). The association between office design and performance on demanding cognitive tasks. *Journal of Environmental Psychology, 42*, 172–181. doi: 10.1016/j.jenvp.2015.05.001. Reprinted with permission from Elsevier.

III Seddigh, A., Berntson, E., & Westerlund, H. (2015). *Does personality matter for performance in different office types? A study of how personality and office type interact in relation to self-rated job performance.* Manuscript submitted for publication.

Abbreviations

ANCOVA = Analysis of covariance
COPSOQ = Copenhagen Psychosocial Questionnaire
ICT = Information and communications technology
IFR = Immediate Free Recall
IPIP = International Personality Item Pool
MANCOVA = Multivariate analysis of covariance
MBI-GS = Maslach Burnout Inventory – General Survey

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Introduction

The probability that you, the reader of this thesis, work in an office is rather high. You might be a clerical worker, a professional or have a managerial position. You probably have some understanding of how the office environment can affect your well-being, health and performance. You may believe that an adequate office environment can stimulate you while an inadequate environment hinders your development. You have perhaps thought that what is an adequate office environment depends on several aspects, such as what type of task you do and what the demands of your work are. Possibly you reason that who you are as a person might influence your perception of the office environment. You might believe that your extrovert friend prefers working in settings where people can easily interact while your introverted colleague prefers quiet areas for work that are more suitable for reflection.

This thesis focuses on these contemporary topics and aims to empirically improve our understanding of how office type—that is the spatial design, the number of occupants in the office environment and whether or not employees are provided with an assigned desk—is associated with employees' abilities to function well at work. It focuses on both the concentration demands of the job and individual differences in personality, this thesis examines in a nuanced way the effect of office type on indicators of health and performance. It empirically tests hypotheses and explores the relationship between office type, personality and contemporary ways of working on employee health and performance.

Setting the scene

In developed countries, the proportion of the workforce employed in manufacturing jobs, blue-collar, and less advanced clerical work has decreased while knowledge work conducted by professionals and managers has followed the opposite trend, leading to an increase of the proportion of office workers—also called white-collar workers—in relation to workers who do not work in offices. Foreseeing this development, expectations were raised that in the UK and USA around 70% of the working population would be based in offices by the end of 20th century (Donald, 1994). Although this expected development seems to have been overestimated in the US, recent statistics suggest that, in

2013, 39% of workers were white collar while 61% were blue collar (The Henry J. Kaiser Family Foundation, 2015), in Sweden today there are slightly more white-collar workers than blue-collar (Larsson, 2012). Therefore, in Sweden, a higher percentage of the population is working in offices rather than on industry floors, which increases the relevance of learning more about how the office environment is associated with employee health and performance: the purpose of this thesis. Another contribution made by this thesis is to investigate the possibility that individual differences in personality as well as the concentration demands of the job moderate the effect of office type on employees. That is, depending on who you are and what types of job you have, different types of offices might suit you well or less well.

The development of office environments to current designs

As changes in the labour market have brought a significant part of the workforce to the office environment from industry floors, work-environment research has shifted in focus from unfavourable physical working conditions (Srivastava, 2007) to a concern with the psychosocial work environment (Karasek & Theorell, 1992).

Other aspects that have dramatically contributed to changing ways of working are advances in construction, the fluorescent lamp, ventilation and information and communications technology (ICT) (Myerson, Bichard, & Erlich, 2010; Sundstrom, 1986). Developments in construction techniques have made it possible to construct larger offices with fewer bearing walls. Better fluorescent lamps have decreased our dependency on natural lightening. As a result, it is today possible to construct more spatially open office environments rather than cell offices, that is office rooms with four walls and a door mainly suitable for one person (Sundstrom, 1986). In buildings where few internal walls have a weight-bearing function, spaces can be created to fit the existing tenant's needs or be refurbished rapidly to fit the needs of new tenants. Hence, the office environment can more easily be adjusted to be appropriate for different uses. These reasons together with attempts to use space more efficiently (Vos & van der Voordt, 2001) and also communication benefits, can perhaps explain why open-plan offices today have grown in popularity and why many organisations, within both the private and public sector, have adopted these office designs.

The push towards flexibility does not end with how spaces are constructed but extends also to how work is conducted. Developments in ICT have made work less dependent on location and for many professionals it is possible to work both anywhere in the office or away from the office such as in a café, library or at home. In fact, when the occupancy diversity factor is calculated—that is, what percentage of the office is occupied at any given time during office

hours—these assessments show that occupancy in the office as a whole peaks at 50% to 80% (Davis & Nutter, 2010; Duarte, Van Den Wymelenberg, & Rieger, 2013; Mahdavi, 2009). Occupancy of individual desks is even lower, which has incited organizations to take the ideas about flexible ways of working even further. Today, many organisations have adopted diverse solutions to flexible ways of working that have in common that the employees do not have an individually assigned desk but instead choose a desk, often in an open-plan office environment, depending on the task at hand. In contrast to traditional, plain and homogeneously furnished open-plan offices that once gave a dull picture of open office environments, these flexible office environments are usually colourful, ergonomically modern and aim to provide a creative work environment for employees. Usually, organisations that adopt this type of solution also give employees opportunities to work outside the office and consider the office solution as attractive to the younger part of the workforce. Some examples of organisations that have adopted these types of flexible ways of working in Sweden are private companies such as Swedbank and Nordea (two of the largest banks in Sweden) and Omega Pharma (a company that markets health and personal care products) but also public companies such as The Swedish Social Insurance Agency.

Open-plan office environments and flexible ways of working are therefore affecting more and more people. Concerns have been raised regarding their effect on employees, although little is known about the impact of office type on employee health and performance (De Croon, Sluiter, Kuijer, & Frings-Dresen, 2005). Previous research is unsatisfactory in two aspects. Firstly, it does not differentiate between and compare different types of open-plan office environments to other office types (see Bodin Danielsson & Bodin, 2008; Bodin Danielsson, Chungkham, Wulff, & Westerlund, 2014 for some exceptions). As has been shown in previous studies (Bodin Danielsson & Bodin, 2008), depending on the number of employees working in a single open-plan office, the effect of the office environment may vary. The less differentiated classification can be considered a problem, for example, if there are actually an optimum number of people to share an open-plan office, and having fewer or more people working in such a space has a negative effect. Secondly, previous research has focused less on whether other characteristics—such as individual differences and the concentration demands of the job—may interact with office type to affect employee health and their ability to carry out their task. Therefore, more attention needs to be paid to the impact of the office environment by using a more differentiated definition of office types and also to considering aspects that might moderate the main effect of office environment on employee health and performance.

The fit between person and environment

Over the last decade, office research has focused on the association between the physical work environment and health and performance outcomes (Ashkanasy, Ayoko, & Jehn, 2014; De Been & Beijer, 2014; Haapakangas, Hongisto, Hyönä, Kokko, & Keränen, 2014; Inamizu, 2013; Kim & de Dear, 2013; Pejtersen, Feveile, Christensen, & Burr, 2011), usually showing the disadvantages of open-plan offices as compared to cell offices. But even if the general effects on employees are driven by office type, differences in employees' attitudes, experience, preferences and needs may moderate this effect. For example, consider two employees working in the same open-plan office. Presume that the working conditions are poor and most employees are dissatisfied with aspects in the physical work environment for example with noise. If one of these employees has had positive experiences previously when working in an open-plan office environment, he or she may be less likely to blame the noise levels on the office's design, than one who has not had such a previous experience. Hence, experiences people have had from working in different settings may impact on their perceptions of problems in their current work environment. Similarly, if two individuals have different preferences towards office types depending on who they are as persons, they may differ in their ability to conduct the same task when working in similar office type. In a similar manner, for two employees conducting different types of tasks, their task may require different activities that make similar office environments more suitable for one and less suitable for the other.

These types of factors, such as previous experiences, individual differences in personality and concentration demands of the job, that may moderate the main effect of office type on employees' health and performance have been given little attention in the research literature (Oldham, Cummings, & Zhou, 1995). This thesis focuses on two of these possible moderators: the concentration demands of the job and individual differences in personality. Below, a more extensive background review is provided to these two factors that may moderate the main effect of the office type on employees.

General fit theories and research

The fit between different person characteristics and the environment has been of interest in the realm of organisational psychology. The basic premise of person-environment fit is that when characteristics of employees and the work environment are aligned or fit together, positive outcomes such as satisfaction, commitment, performance, adjustment, and reduced stress and turnover can be expected at the individual level. In contrast, a poor fit can be expected to result in more negative outcomes and may, in the long run, affect the effectiveness and long-term survival of the organisation (Oldham et al., 1995).

Before focusing on the person-environment fit, researchers studied fit from either the so-called "macro level" or from an interactionist perspective. The macro level concerns internal and inter-organisational design and focuses on the relationship between the environment and organisational effectiveness. To give some examples, the focus at the macro level has been on organisational strategy, structure and internal processes (Ostroff & Schulte, 2007; Schneider, Goldstein, & Smith, 1995; Schneider, Kristof-Brown, Goldstein, & Smith, 1997). The interactionist perspective on the other hand emphasises that behaviours, attitudes, and cognitions of individuals can only be understood as an interaction between people and their context, hence neither the situation nor traits alone primarily determine an individual's response (Ostroff & Schulte, 2007; Pennings, 1975). However, interactionism does not state how the personal and situational or environmental aspects might interact to generate positive effects (Schneider, 1983; Terborg, 1981), while theories about the person-environment, inspired by the need-press model of Murray (1938), do so by suggesting that higher similarities between person and environment dimensions yield positive outcomes (Caplan, 1987; Graham, 1976). Hence, a better fit between the individual and the organisation, between the individual and concentration demands of the job, between person and person, and between groups and organisations has been linked to outcomes such as higher job satisfaction and productivity (Kristof-Brown & Jasen, 2007; Su, Murdock, & Rounds, 2015).

Is the fit between the office environment to person and task relevant?

While fit theories are mostly concerned with the fit between person and the work organisational aspects, office type is another dimension that may interact with job type and person on outcomes related to health and performance (Ashkanasy et al., 2014). The basic premise is straightforward. Based on who you are and what you do, your performance and health may vary depending on the spatial design and the functionality of the office. This fit may be measured in terms of certain characteristics of the environment such as noise, lighting conditions, ventilation and the amount of space available per employee or by focusing on the total physical design of the office environment and ways of working. This thesis focuses on the spatial design, the number of occupants in the office environment and whether or not employees have an assigned desk—also referred to as *office type*.

Concerning individual differences, different office types may fit different individuals depending on person-related characteristics. Person-related characteristics may include personality, previous experiences and age, or needs that are a consequence of certain disabilities or health problems such as hearing disabilities or physical disabilities. For example, people with hearing problems might have larger difficulties inhibiting noise than the unimpaired, if they

work in an open-plan office (Jahncke & Halin, 2012) rather than in a cell office. People with a physical impairment may have larger difficulties in cell offices with more doors, doorsills and narrow corridors. However, also variation unrelated to impairments may exist. For example, people who enjoy the company of others may find it more stimulating to work in open-plan offices, while people who are less good at inhibiting irrelevant stimuli may have more difficulties in such environments. It is important to remember that people with disabilities are a large group that needs to be given proper possibilities to conduct their work: in Sweden in 2008 about 14% had some sort of hearing impairment of which 50% were of working age (Aronsson & Göransson, 1999; Brener, Billy, & Grady, 2003; HRF, 2008). Nevertheless, given the general lack of research focusing on the interaction between office type and person this thesis focuses on the variation that is within the healthy range. In so doing this thesis investigates the effect of office type from a more wide-ranging perspective.

In the same vein, different office types may fit different jobs well or less well. For example, open-plan offices, where the lack of walls enables awareness of others in the landscape, may be thought to fit better for tasks that require interaction, while offices with higher privacy, for example cell offices, should fit better for individual work tasks that demand concentration. That is, if the work task requires interaction and information sharing, the lack of walls provides visibility and easier oral communication. If, on the other hand, the work task requires privacy and concentration, walls may protect employees from irrelevant stimuli in their surroundings. In support of these suggestions, research has shown that professionals and managers, who can be assumed to have more demanding jobs compared to clerks, reported more problems after moving from cell offices to open-plan offices (Fried, Slowik, Ben-David, & Tiegs, 2001). In the present thesis, the focus will be on the concentration demands that the job places on the employee rather than focusing on the role or the position of the employee.

Theoretical and conceptual models of how office type impacts employees

While reduction of facility management costs is one important incentive for introducing open-plan office environments and flexible ways of working, the health and performance of employees is another important aspect that contributes to organisations' profitability (Eggerth, 2015). If working in open-plan office environments or working in flexible ways add value, then they should lead to a synergistic economic benefit generated by simultaneously reducing costs and enhancing productivity. However, if working in open-plan office environments or working in flexible ways are less suitable, then the economic

benefits associated with these ways of working must exceed the cost associated with lower health and performance of employees in order for organizations to gain a net benefit (see also Ashkanasy et al., 2014 for a similar discussion).

A relevant question is how office type may impact employees health and performance. Two conceptual models (De Croon et al., 2005; Vischer, 2008) have been proposed relating to how employee health and performance may be impacted by office type and other factors. De Croon et al. (2005) present a conceptual model in which office type and working conditions through the means of short-term reactions—including physiological and psychological responses—lead to long-term effects on employee health and performance. Vischer (2008), on the other hand, suggests that office users' satisfaction and well-being increases if the office environment address the need for physical comfort, that is fulfil basic human needs such as safety, hygiene and accessibility. Thereafter the well-being of employees may increase further if the office environment supports users' tasks, also called functional comfort. And lastly, what leads to the highest level of satisfaction and well-being is psychological comfort, that is if the person senses a feeling of belonging, ownership and control over the workplace.

These models suggest the importance of the physical office environment in that it affects outcomes related to employees' health and performance, which should have an effect on the organisation's performance.

Aims of the thesis

The labour force in the western countries is more and more concentrated in offices as the proportion of knowledge work in relation to industrial production grows. This development should focus research attention on how the office environment can facilitate or hamper task completion and positively or negatively affect the health of the work force. Having said that, the effect of the office environment might not be direct but influenced by who you are and what you do. Therefore, research focusing on the effect of office environment should also be concerned with related moderators that may impact how people are affected by the office environment.

Hence, and as is illustrated in Figure 1, the purpose of this thesis is to add to current knowledge about the main effect of office type, the interaction effect between office type and the concentration demands of the job, and the interaction effect between office type and personality on outcomes related to both health and performance. The studies in the present thesis are based on a field project. The general idea is that, depending on the degree of concentration the

task requires and depending on who the person is, the effect of office type on the outcomes may vary.

Previous research (e.g., Pejtersen et al., 2011) has shown that an open-plan office is associated with disadvantageous health outcomes in comparison with cell offices. In addition, when it comes to distraction and satisfaction related outcomes, such as satisfaction with privacy, noise-level but also ease of interaction, findings are usually in favour of cell offices (Kim & de Dear, 2013). However, concerning performance, the effect of office type is less convincing and the findings are quite inconsistent (De Croon et al., 2005).

The office literature has mostly been concerned with employees in cell offices in comparison to those in open-plan offices, and therefore a more differentiated categorization of office type could reveal variations in employees heath and performance that otherwise cannot be detected. Hence, a more differentiated definition is used in this thesis, which not only distinguishes between the size of the open-plan office environment but also includes flex offices where employees do not have assigned work stations (Bodin Danielsson & Bodin, 2008).

Furthermore, the main effect of the office type may also be moderated by the concentration demands of the job and individual differences in personality. That is, depending on who you are and what you do, different office types may be better or worse for your health and performance.

Consequently, in the present thesis, the focus is placed on the main effect of office type, the interaction effect between office type and work characteristics, and the interaction effect between office type and personality upon outcomes related to employee health and performance.

The *general aim* of this thesis is to improve the understanding of how different office types together with individual differences in personality and concentration demands of the job relate to outcomes relevant for employees and companies. More specifically, the aim of this thesis is to investigate, how office type affects employee 1a) health and 1b) performance, and if 2a) concentration demands of the job and/or 2b) individual differences in personality moderate these effects. These aims are addressed in three papers.

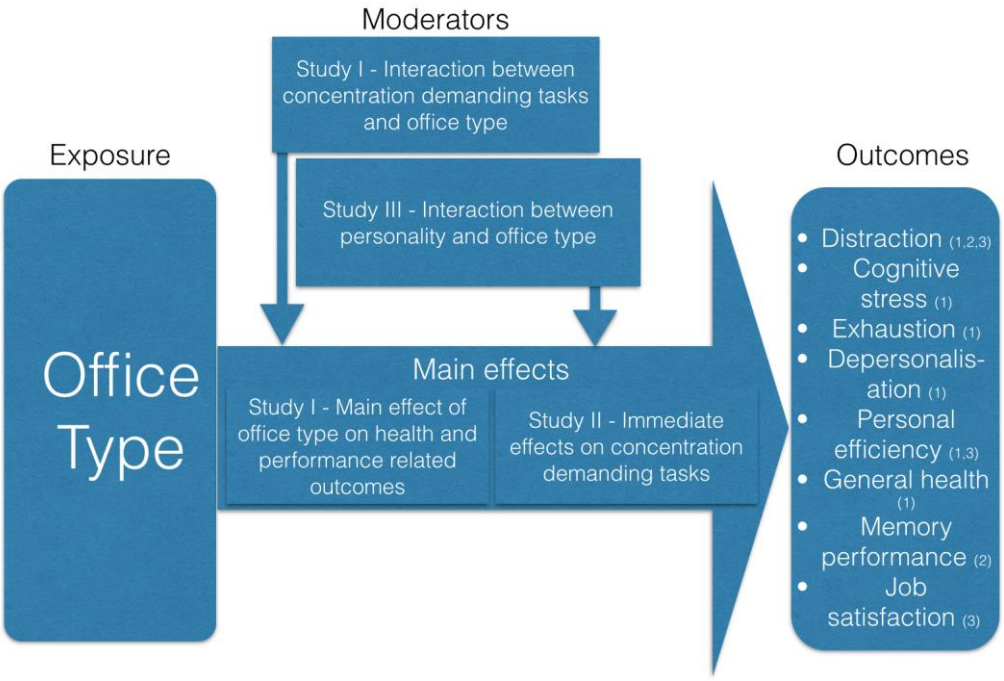

Figure 1. A conceptual figure, describing the structure of the present thesis. Office type includes: cell offices, shared rooms, small open-plan offices, medium-sized open-plan offices, large open-plan offices, flex offices. 1 = included in study I, 2 = included in study II, 3 = included in study III.

Study I

Study I focuses first on how office type in general is associated with health and performance, indicated by distraction, depersonalization, professional efficiency, cognitive stress, exhaustion, and general health. Thereafter the interaction effect between office type and concentration demands of the job is investigated in relation to the same outcomes. In other words, this study investigates the main effect of office type on employee health and performance, and the joint effect of office type and concentration demands of the job on employee health and performance. Hence, Study I addresses aims 1a, 1b and 2b.

Study II

While Study I is based on a cross-sectional design, Study II uses a within and between subject design and investigates how performance on a memory test that requires concentration is affected in different office types by comparing performance during a quiet baseline with performance during normal working

conditions. In other words, this study investigates how performance on demanding memory tasks varies during normal working conditions as compared to quiet times in different office types. Hence, Study II addresses aim 1b.

Study III

Study III shifts attention to individual differences in personality. It investigates the effect on performance outcomes of the interaction between office type on the one hand and the Big Five traits and stimulus screening ability on the other. Consequently, Study III investigates whether employees' perceptions of distraction, job satisfaction and professional efficiency are affected by the combination of office type and personality characteristics, and addresses aim 2b.

The history and present of office environments

In this thesis, the main exposure in focus is office type. The next section will first present the historical background regarding the evolution of office environments and subsequently present how different office types are defined in contemporary scientific literature.

The development of office environment

Fredrick Taylor's work on management practice (Taylor, 1911) had a significant impact on the development of office spaces over the twentieth century. Taylors' ideas regarding the importance of order, hierarchy, supervision and depersonalization were integrated into the architecture of office buildings (Duffy, 1997). But while European countries shortly after Second World War begun to rethink the contribution of these ideas of Taylorism when it came to office work settings, in Northern America these ideas had established themselves more firmly. Northern Europe and Northern America steered in different directions. In Northern Europe, office environments were designed with the aim of enhancing interaction among staff, but office spaces in Northern America mainly emphasized corporate discipline (Duffy, 1997; Sundstrom, 1986).

Nevertheless, ideas about new ways of working have emerged during recent decades that challenge conventional office practices. While the North European office has focused on creating *effectiveness* by adding value, the Japanese office has focused on *efficiency* by driving down occupancy costs. However, the future office should strive to become both efficient and effective—that is, it should use space more efficiently and add value by creating a good physical work environment for employees (Duffy, 1997).

The definition of office in contemporary research literature

Variations in the office type or way of working can be explained by two variables that describe how work is conducted, which Duffy (1997) calls interaction and autonomy. Interaction stands for the need for face-to-face contact that is necessary to carry out the work task in the office. Autonomy expresses the degree of control, responsibility and discretion employees need to have over the content, method, location and tools of the work process. The combination of autonomy and interaction creates the office functional feature, which, together with the spatial layout, defines four office types described by F. Duffy (1997): the hive, den, cell and club.

Hive offices are characterized by both low autonomy and low interaction. In hive offices you find impersonal and screened desks arranged in an orderly fashion in an open-plan spatial solution. Hive offices are suggested to be appropriate for accommodating employees who conduct individual routine tasks that rapidly get automatized. Routine banking and data-entry or processing are two examples of work tasks suitable for hive offices according to F. Duffy (1997).

As the hive, the spatial solution of *den offices* is open. The den supports tasks with high need for interaction but low need for autonomy. Some examples of work that are associated with these conditions are advertising or design. Den offices are created for group work and often provide various interactive settings while each worker still has a designated desk (Duffy, 1997).

In contrast to hive and den offices, *cell offices* are spatially private. This office type is either a desk located in an open-plan office environment with high screens surrounding the desk as seen in North American offices or an enclosed room with a desk for one individual. Cell offices suit tasks with low need for interaction but high need for autonomy and should be designed to provide for a variety of tasks. Professionals that by tradition have been working in such environments are lawyers, managers, and accountants (Duffy, 1997), however, today these professionals also work in spatially more open environments.

Finally, while employees in hive, den and cell offices all have assigned desks, employees working in *club offices* do not. Instead, there are several types of work settings available, each designed for specific activities, which are used on a need-to-use-basis. The occupancy level usually shifts periodically in organisations that adopt this office type. The type of work suitable for the club office demands both much autonomy and interaction, hence the club is appropriate for knowledge work—that is, tasks that are non-routine and demand considerable amount of judgement and intellectual processing. Companies

that incorporate such offices are usually highly dependent on knowledge sharing in combination with highly self-governed and educated staff.

In contemporary research about office environments cell offices and, to some extent, club offices are described with other labels. For example, cell offices are referred to as traditional offices, individual office rooms or enclosed offices, while club offices are also called activity-related or activity based office, flexible office, multi-space office or non-territorial office (Boutellier, Ullman, Schreiber, & Naef, 2008; Brennan, Chugh, & Kline, 2002; De Croon et al., 2005; Hedge, 1982). It is also worth mentioning that, although many people would say that the flexible ways of working with undesignated desks is rather new, the concept was actually introduced and documented as early as the 1970s (Allen & Gerstberger, 1973).

When it comes to offices with open spatial designs, researchers seem less prone to differentiate between den and hive offices, hence in research the functional differences between these two office types suggested by Duffy (1997), are forgotten. Given that the low interaction possibilities in hive offices are proposed to be inappropriate for knowledge work, the research literature would gain from differentiating between hives and dens. In so doing, better understanding could be created regarding what types of office environments are beneficial or harmful for knowledge workers' health and performance.

However, some research has been conducted that has used a more differentiated categorisation of office type. Although it has not fully incorporated the definition of Duffy (1997), it has categorised the open-plan office environment depending on the number of occupants in the office environment. This research indicates that the amount of occupants in open-plan offices is important. For example, Pejtersen et al. (2011) used the classification of a private office with one occupant, shared rooms with two occupants, shared rooms with 3–6 occupants, and open-plan office with more than 6 occupants. Bodin Danielsson and Bodin (2008) on the other hand used another categorisation that also included flex offices, which are comparable to the club office. In their classification, cell offices are defined as single room offices, shared-room offices are shared by two to three people, small open-plan offices are shared by 4–9 people, medium-sized open-plan offices are shared by 10–24 people, and large open-plan offices contain more than 24 people (Bodin Danielsson & Bodin, 2008).

The functional features of free seating and greater possibilities to work away from the office separate flex offices from the other office types. In the same vein, high control over the physical office environment distinguishes cell offices from the rest of the open-plan office environments. However, the theoretical basis regarding the number of occupants that should delimit different

open-plan offices is weak. Although one could argue that more people in the office environment should for example lead to more irrelevant stimuli, an office with 10 employees should be much more similar to an office with 9 employees, than to one with 20 employees. Nevertheless, the definition of Bodin Danielsson and Bodin (2008), would classify the open-plan offices with 10 and 20 employees as medium-sized open-plan offices, while the office with 9 employees would be classified as a small open-plan office (see also Haynes, 2008 for a general discussion regarding the lack of a strong theoretical framework concerning the physical work environment).

That said, the definition of Bodin Danielsson and Bodin (2008) is the most differentiated one used for research purposes and provides an opportunity to study whether the size of open-plan office environment matters when it comes to employee health and performance. For these reasons, the present thesis uses the definition of Bodin Danielsson and Bodin (2008) when addressing the main effect of office type, the interaction effect between office type and concentration demands of the job, and the interaction effect between office type and individual differences in personality on indicators of both health and performance.

Outcome variables associated with office type

As mentioned previously there are at least two conceptual models that discuss how office environments may affect employees (De Croon et al., 2005; Vischer, 2008). According to De Croon et al. (2005), the office type *per se* affects employees both in the short and the long-term, while the model of Vischer (2008) focuses on how appropriate and functional the office environment is for office work. Below, findings related to office type are presented. The variables that will be focused upon are distraction, satisfaction, health, sickness absence and performance, which are outcome variables that are in focus in this thesis.

Distraction

One of the most recurring outcome measures in the scientific office environment literature is perception of irrelevant stimuli presumably caused by noise. Laboratory studies have found that noise in general, but particularly irrelevant audible and intelligible speech from colleagues, both distracts individuals and negatively affects performance (Banbury & Berry, 2005; Haka et al., 2009; Virjonen, Keränen, Helenius, Hakala, & Hongisto, 2007). The higher presence of noise in open-plan offices rather than in cell offices is assumed to have a negative effect on employees, which respondents in laboratory studies do not seem to habituate to (Banbury & Berry, 2005).

Field studies seem to confirm the results found in laboratories. For example, Hedge (1982) found that employees working in open-plan offices consistently reported problems associated with lack of privacy and increased disturbances. Becker, Gield, Gaylin, and Sayer (1983) reported that employees in open-plan offices in comparison to those working in private or shared offices reported dissatisfaction with the amount of privacy, and an inability to speak without being overheard. In line with the findings of Becker et al. (1983), Kaarlela-Tuomaala, Helenius, Keskinen, and Hongisto (2009) reported increased levels of distraction and loss of privacy after relocation from cell offices to open-plan offices. Additionally, Pejtersen, Allermann, Kristensen, and Poulsen (2006), focused on ambient factors and found a positive dose-response relationship between the number of people sharing an office and the level of noise they reported. Taken together, these studies indicate that people working in open-plan office environments report distractions to a higher degree than people working in cell offices.

The absence of partitions in open-plan offices raises questions about the possible increased risk for employees of becoming distracted in open environments compared to those working in more private offices. However, if people are distracted but able to conduct their work without performing less well or without their health being affected, then being distracted might not be a major problem. Nevertheless, as also suggested by Davis, Leach, and Clegg (2011), if people to a large extent are distracted, it should lead to their performance being affected in the long run given that their task completion is hampered. In fact, Becker et al. (1983) found that employees in open-plan offices reported more perceived difficulties working efficiently and more problems regarding concentration, aspects that may be related to distraction. These suggestions can therefore explain why distraction is a common measure used in the office research literature. These suggestions are also the reason why all three studies in this thesis include measures of distraction.

Satisfaction-related outcomes

Except distraction, another outcome that has been given attention in the scientific literature concerning work environment is satisfaction. For example Oldham and Brass (1979) found that employee satisfaction and internal motivation decreased after relocation to an open-plan office environment from cell offices. Brennan et al. (2002) also conducted a longitudinal study based on a small sample of 21 employees who moved from cell offices to open-plan office environments. The authors found that the employees were less satisfied with team member relations, their perception of job performance, physical stress of the open-plan office designs, and the physical environment of the open-plan offices.

A more recent cross-sectional study (Kim & de Dear, 2013) found similar result and showed that employees in cell offices report higher satisfaction with sound and visual privacy. While these findings can be expected, the authors also showed that employees in cell offices reported the highest satisfaction regarding ease of interaction, temperature, air quality, amount of light, and comfort of furnishing. Another recent study (De Been & Beijer, 2014) also suggests that working in open-plan office environments with quiet rooms (in this specific study called combi-offices) or in flex offices were associated with lower satisfaction with the productivity support, privacy and concentration than working in cell offices or in shared room offices. They additionally found that employees working in cell offices and shared room offices were less satisfied with the architecture and the layout of the office in comparison with employees in the two other office types. A study by De Been and Beijer (2014) found that employees reported more satisfaction with communication in open-plan office environments when compared to people working in cell offices and shared room offices. This is in line with previous suggestions finding that the absence of partitions between desks facilitates encounters and communication in open-plan offices (Davis, 1984) while it contradicts the findings of Kim and de Dear (2013), mentioned above, who found that employees in cell offices reported the highest satisfaction regarding ease of interaction.

All in all, different aspects of satisfaction have been focused upon in previous research. This research shows that employees working in cell offices report higher level of satisfaction. In this thesis, the focus is on job satisfaction, rather than satisfaction with the physical environment or satisfaction with communication, mainly because that theoretical models have linked job satisfaction to long-term health and performance (De Croon et al., 2005; Oldham, 1988). Given that performance based on self-report data might be unreliable, job satisfaction may be a proxy for understanding employees' ability and motivation to function at work. Therefore a measure of job satisfaction (Hellgren, Sjöberg, & Sverke, 1997) is included in study III.

Health problems and sickness absence

In addition to distraction and satisfaction, researchers have given attention to aspects that are more related to health when studying the effect of office type (Bodin Danielsson & Bodin, 2008; Bodin Danielsson et al., 2014; Jaakkola & Heinonen, 1995; Pejtersen et al., 2011). These findings are quite consistent in showing the benefits of cell offices when compared to more open and less private office types. For example, in Finland, Jaakkola and Heinonen (1995) found that room-sharing in contrast to working alone is associated with 35% increased risk of having more than two episodes of common cold during a one-year period. Furthermore, regardless of office type they also found that

those who had young children had a 45% increased risk. The comparison is interesting given that it tries to put the impact of office type into a broader context, which should be important when trying to understand the relevance of the effect of office type on health outcomes.

Another study conducted in Sweden (Bodin Danielsson & Bodin, 2008) indicated that employees in small and medium-sized open-plan office environments reported the most ill-health, followed by employees in shared room and large open-plan offices. In this study, employees working in flex and cell offices reported the best health and well-being. Based on a representative sample of the Swedish population, Bodin Danielsson et al. (2014) found a higher rate of short-term sick leave amongst women, but not men, working in open-plan office environments, regardless of their size. For men there was an increased risk of short-term sick leaves in flex offices, which contradicts the previous finding of Bodin Danielsson and Bodin (2008) suggesting a positive effect of flex offices. The authors also investigated long-term sick leave and found that women in large open-plan offices had a higher rate of long-term sick leaves compared to men (Bodin Danielsson et al., 2014).

Finally, yet another Nordic study, this time conducted in Denmark, reported that office types with one occupant reported 4.9 days of sickness absence, while people sharing rooms reported between 7.1 to 8.1 days of sickness absence within the last year (Pejtersen et al., 2011).

These studies are consistent in showing more health problems in open-plan offices as compared to cell offices, while more studies are needed about the impact on flex offices on employee health given that these findings are inconsistent. However, what causes the health problems in open-plan offices is unknown. Pejtersen et al. (2011) summarizes five different mechanisms that may explain the differences observed. These mechanisms might be a) higher exposure to noise in open-plan office environments, b) differences in ventilation systems—while open-plan offices usually have mechanical ventilation, cell offices are mostly equipped with natural ventilation, c) exposure to viruses which presumably is higher in open-plan offices, d) differences in the psychosocial working environment, and e) presence of other humans when working which might lead to lower employee autonomy, which may act as a stressor and in the long run to burnout and sickness absence (Pejtersen et al., 2011).

Poor health conditions may affect performance both by absenteeism and through worsening health leading to fatigue or cognitive problems such as worsened memory function. Furthermore, focusing on health is also important given that an organisation that cares about improving the well-being of employees may brand itself as a healthy organisation, hence improving its ability

to attracting talents and future work force. Given the importance of employees' health several health related measures—such as burnout, cognitive stress and general health (Kristensen, Hannerz, Høgh, & Borg, 2005; Leineweber, Baltzer, Magnusson Hanson, & Westerlund, 2013; Schutte, Toppinen, Kalimo, & Schaufeli, 2000)—are included in Study I to investigate the effect of office type on employee health.

Performance outcomes

The performance of the organisation depends on the performance of the employees (Dess & Robinson, 1984). By means of cognitive tests Perham, Banbury, and Jones (2007) investigated performance on a memory test in three different conditions, two more or less noisy conditions, and one completely quiet condition. Although performance in the two noisy conditions did not differ, performance was significantly worse in these two conditions compared to the quiet control. Another laboratory study compared the effect of high and low noise. In this study it was found that low in contrast to high noise was associated with better recall on a working memory test (Jahncke, Hygge, Halin, Green, & Dimberg, 2011). Although these laboratory studies mimicking office environments give interesting insights into how noise can affect employees performance, field studies are needed to investigate how performance is affected in authentic office types (Jahncke et al., 2011).

In order to investigate overall performance, a subjective measure of performance, professional efficiency (Schutte et al., 2000), was included in Study I and III. In Study II, a memory test (Nilsson et al., 1997), is used to measure the immediate effect of office type on employees performance.

All in all, the variables included in all three studies of this thesis aim to capture different aspects of employees' health and their ability to be productive in relation to office type. The variety of measures included in the study of this thesis helps investigate both the long-lasting effect of office type on employees—such as on general health and professional efficiency—and also more immediate effects such as performance on concentration demanding tasks. In so doing, the present thesis aims to investigate the effect of office type on employees from different perspectives. This thesis also considers the moderating effects of personality and concentration demands of the job. These possible moderators are discussed below.

Moderators

The effect of office type may vary depending on the employee's personality and what tasks the employee has. This section presents theories and constructs

that address how the work task and individual differences in The Five Factor Model, also called the Big Five traits, and stimulus screening ability may interact with office type.

Employees response to environmental stimuli when conducting complex tasks

Proponents of open-plan offices suggest that the open layout creates better opportunities for collaboration and communication (Davis et al., 2011; Lee & Brand, 2005) while it is a less good option for work demanding higher cognitive functions (Davis et al., 2011). Hence, the effect of office type may be moderated depending on concentration demands of the job. There are several theories that could explain why office type may interact with concentration demands of the job on employee health and performance. Below these theories are presented.

Arousal and stress responses to environmental stimuli

The arousal hypothesis outlines how the environment can impact performance (Yerkes & Dodson, 1908). It suggests that employees perform most effectively at moderate levels of arousal. As the arousal departs from the optimal range, regardless if it declines or rises, performance is thought to decline. What may be considered the optimal range of arousal depends on the task. For complex tasks, the optimal level of arousal is lower than for tasks that are simple (Anderson, Revelle, & Lynch, 1989; Duffy, 1957; Hebb, 1949; Yerkes & Dodson, 1908).

In workplaces, noise and temperature can be intense physical stimuli in such ways that they can elicit arousal. The arousal can be elicited through both physiological and psychological processes. That is, temperature can lead to increased arousal through body mechanisms for maintaining constant temperature while noise can trigger psychological reactions, for example, creating readiness to handle plausible threats (Sundstrom, 1986).

Stress—that can be defined as a form of psychological and physiological mobilization in response to *perception* of adversity, demand, challenge, or threat (Lazarus, 1966)—is assumed to have the same consequences on the employee's performance as does arousal. Mild stress may improve performance on simple tasks but degrade performance on complex tasks, but even the simplest task is hampered by severe stress (Berkun, 2000).

Environmental effects on cognitive functions

Cognitive theories may also help to improve the understanding of how the environment affects performance. Early cognitive theories related to attention

assume that each person has a finite attention span and that stimuli present in the surroundings can subtract attention from the task at hand (e.g., Cohen, 1978). Consequently, performance is affected negatively until the individual is able to shift attention back to the task. More recently Lavie, Hirst, de Fockert, and Viding (2004) suggested a load theory of attention which contains two mechanisms of selective attention. According to load theory, during high perceptual load, irrelevant stimuli are prohibited from entering the attention sphere simply due to insufficient capacity to process irrelevant stimuli. In situations with low perceptual load, irrelevant stimuli are perceived much more easily. However, higher cognitive functions, such as working memory, are able to inhibit these stimuli and maintain current processing priorities in order to make sure that irrelevant stimuli do not shift focus from the task at hand. When cognitive capacities are highly loaded, for example when much mental effort is used for solving a complex task, the cognitive control functions have fewer resources to inhibit irrelevant stimuli, thus increasing the risk that the individual will be disturbed.

What are adequate settings for different jobs?

These theories concerning cognitive functions, and psychological and physiological responses to environmental stimuli suggest that, for complex tasks that require elaboration and in-depth processing, irrelevant environmental stressors risk negatively affecting task completion. According to these theories, it would be important to acquire an understanding of the complexity and demand that an employee's task places on their cognitive system when assessing how different spatial environments influence an employee's possibilities to perform their duties. In fact, there are some studies that have given attention to this issue. For example, Fried et al. (2001) showed that high-density (i.e., in terms of the number of people and enclosures) offices, as compared to low-density offices, are associated with lower organisational commitment, job satisfaction and co-worker satisfaction for people with long tenure and high job complexity. A study by Zalesny and Farace (1987) focused on work position as a way to assess the complexity of the work that employees carried out. They showed that managers and professionals reported more problems after moving to an open-plan office from cell offices, while clerical employees with less advanced work tasks reported fewer problems. The results of these studies are in line with the theories mentioned above. In this thesis, the impact of task complexity on employees' abilities to function at work is investigated further by focusing on different office types, including different sizes of open-plan offices and flex offices.

Individual differences in personality

In addition to type of work tasks moderating the effects of office design, it has been suggested that individual differences may moderate how individuals respond to their environment. However, only a few studies have attended to this issue (Oldham et al., 1995). This thesis focuses on stimulus screening ability (Mehrabian, 1976) and the Big Five personality traits (Goldberg et al., 2006). Both these concepts are relevant given that they address different characteristic of employees. Stimulus screening ability focuses on the ability to disregard irrelevant stimuli and therefore those employees with a high ability in this area may be less affected when working in office types associated with more irrelevant stimuli. Personality traits may also moderate the main effect of office type if these traits interact with office type. For example, extrovert employees who like the company of others may be stimulated when working in busy office types while introverted employees may report dissatisfaction. Below, these possible moderators are discussed.

Big Five personality traits

Research within the realm of personality tries to map the most important ways in which individuals differ in stable emotional, interpersonal, experiential, attitudinal, and motivational style (McCrae & John, 1992). In the middle of the 20th century, the psychologist Raymond Cattell developed a relatively complex taxonomy of individual differences that consisted of 16 primary factors and 8 second-order factors. Later research that tried to replicate the latter taxonomy usually concluded that 5 factors accounted for the best fit with the data rather than 8 factors and these 5 factors came later to be called the Five Factor Model. Further research in the end of 20th century provided compelling evidence for the robustness of the five-factor model by indicating that these factors were to be found even if different instruments were used, in different cultures and with a variety of samples (Barrick & Mount, 1991; Costa & McCrae, 1985, 1989; Norman, 1963; Tupes & Christal, 1962).

The five factors, also called traits, are extroversion, agreeableness, conscientiousness, emotional stability (also called Neuroticism), and imagination (also called openness to experience). Extroversion is the traits associated with being sociable, gregarious, assertive, talkative, and active. People high on agreeableness are usually perceived as being courteous, flexible, trusting, cooperative, forgiving, and tolerant. Conscientious people are often described as hard-working, achievement-oriented, and determined. People who load low on the emotional stability scale are associated with being anxious, depressed, angry, worried, and insecure. Finally, imagination is often associated with being cultured, curious, open-minded, and artistically sensitive (Barrick & Mount, 1991).

The relationship between the Big Five personality traits and performance has been investigated in several meta-analyses. The most recurring relationship between the traits and performance is found with conscientiousness and extroversion. However, the other traits, that is openness to experience, emotional stability and agreeableness have also been found to have a positive relationship to performance (Barrick & Mount, 1991; Hogan & Holland, 2003; Tett, Jackson, & Rothstein, 1991). Whether or not the effect of office type on employee performance is moderated differently depending on personality traits is unknown. However, some inferences can be drawn from a study by Oselad (2013), who investigated the relationship between personality and preferences for interaction at work. He showed that for example extroverts and people high on imagination prefer quiet rooms, while people low on conscientiousness prefer club or co-working spaces for sharing information. Agreeable people on the other hand prefer conference rooms or clubs for information sharing. Nevertheless, the question as to whether or not people with certain personality characteristics perform better or worse in different office types remains unanswered.

Stimulus screening ability

Aside from differences in the Big Five personality traits, another aspect that may impact how a person performs in different office types is how he or she is influenced by the stimuli in his or her surroundings. Mehrabian (1977) showed that stimulus screening ability is inversely related to arousability. Individuals who are good screeners are thought to automatically disregard irrelevant stimuli and rapidly habituate to distracting and irrelevant cues. The better the screener the less aroused they get, increasing their chances to perform even in environments with a lot of irrelevant stimuli. Screeners impose a systematic pattern on information, which helps them sort and reduce information rate. It is suggested that nonscreeners lack this ability, so take in more information, leading to higher arousal. Even if screeners and nonscreeners are thought to eventually habituate to comparable levels of arousal, screeners habituate faster. Therefore, the advantage screeners have is noticeable in situations where the level of irrelevant stimuli changes over time and across situations (Mehrabian, 1977).

Concerning stimulus screening ability Oldham (1988) found that, in contrast to screeners, nonscreeners report lower perceptions of crowding after moving from a high density open-plan office to a low density open-plan office environment. This same effect was found for individuals with high need for task and communication privacy. Another study found that low stimulus screening ability and few enclosures surrounding the workplace were associated with low job involvement and high psychosomatic complaints (Fried, 1990). However, no studies have investigated the interaction effect between office type and stimulus screening ability on employees' abilities to perform.

Interaction between office type and personality on performance

All in all there is a gap in the current research literature when it comes to the interaction between personality and office designs on indicators of performance. The work that has been conducted has mainly focused on stimulus screening ability within open-plan office design, and not other types of offices such as cell or flex offices. Therefore, more research is needed to investigate if and in what way individual differences in personality moderate the effect of office type.

It is not easy to propose clear and directed hypotheses regarding how individual differences in personality and office type interact. Actually, the interaction effect between office type and personality on performance outcomes is quite ambiguous. Based on how people with certain traits are described (Barrick & Mount, 1991), the same trait may have different effects in the same office type. For example, when it comes to conscientious people, it is possible to propose that these people are able to handle irrelevant stimuli and stressful work environments better through the creation of good structures. Equally, they might become more stressed than less conscientious people given that their conscientiousness about order and structures might create a constant awareness of shortcomings in the work environment, hence leading them to rate their own performance lower. People who are extroverts might enjoy working in open-plan office environments and perform better through means of higher motivation. But, given that they enjoy socializing, they might also be less prone to focus attention on tasks that do not demand interaction with others, and therefore their overall performance might drop compared to if they had worked in cell offices. People low on emotional stability might find it more difficult to feel at ease with the high amount of stimuli in the open-plan office environment, hence lead to a drop in performance. But, if an open-plan office environment can mediate social support then the effect might be the quite opposite. In view of the lack of both previous findings and strong theoretical frameworks, Study III attempts to shed some light on the role of individual differences in personality in affecting self-rated performance-related measures.

Summary of studies

The empirical part of the present thesis comprises three studies. The first study (Study I) investigated the main effect of office type (cell offices, shared rooms, small open-plan offices, medium-sized open-plan offices, large open-plan offices, and flex offices) and the interaction effect between office type and concentration-demanding work tasks on indicators of both health and performance. The second study (Study II) investigated the effect of cell offices and different sizes of open-plan office environment on performance on a demanding cognitive test. Finally, the third study (Study III) investigated the main effect of office type and the interaction effect between office type and individual differences in personality (extroversion, agreeableness, consciousness, emotional stability, imagination, and stimulus screening ability) on performance-related outcomes. Below the sample, the process of data collection and the type of data gathered is described.

General description of the sample

The data used in the three studies included in this thesis originate from the project "Open-plan office, leadership and health" which was financed in 2010 by AFA insurances (AFA, Dnr: 100300). A total of 3070 employees from 5 organisations were invited to participate in the project. The studies in this thesis have used part of the data gathered in this project. The regional ethical review board in Stockholm approved the project (EPN, Dnr: 2011/5:7). Below the data that was gathered is presented.

Four pilot studies

Prior to the data collection, two pilot studies were carried out in three offices from one of the organisations who participated in the project. In the first pilot study, a paper survey were administrated and in the second pilot study the cognitive tests. In the third pilot study the e-platform was tested from which both the electronic survey and the tests were administrated. As a result of these three studies, some adjustments were made related to the e-survey, the tests and the information that were sent out. A fourth pilot study was conducted to ensure that the total process, the survey and the tests had been adequately designed and were functional.

Inclusion criteria

In order to make the data collection cost-effective, the organisations that were invited needed to have office buildings containing about 50 employees if the building was located within Stockholm or about 100 employees or more if the building was located outside Stockholm. Another criterion was that the organisation should have a variation of offices that comprised different office types. They should, for example, both have cell offices and small open-plan offices or flex offices and large open-plan offices. The different office types could either be present within one single office building or in different ones.

The inclusion and anchoring process

In total, about 10 organisations were contacted. Representatives from the managerial board and from the trade unions within these organisations were informed about the purpose of the study and the data collection. If these instances were interested, a meeting with the managerial board and with the union representatives was conducted in order to brief them in-depth about the project. If they still supported the project, information was requested to select the appropriate number of offices/departments to include from each organisation. Minor office buildings and offices that were under, or were planned to enter, a refurbishment process were identified and excluded. Once a sample of offices/departments had been selected, contact was established with the office or department managers. Each manager was informed about the project and that the organisation overall had taken a decision to participate in the study. The information that had been gathered was checked with the office managers, and thereafter each manager was asked if their office/department could participate in the study. Most managers accepted the invitation, something that might have been related to the fact that the organisations overall were positive about participating.

The names and e-mail address of each employee at each location/department were received from the organisation. This information was confirmed by the office managers before the start of data collection who also were asked to point out employees who were on some sort of leave (for example, parental or long-term sick leave), had quit, were working less than 50% full-time equivalent, were working less than 50% full-time equivalent in the office, and/or had recently been employed (less than three months). These individuals were excluded from the project. The remaining employees were then informed about the project through e-mail and during an information meeting at their office.

After initial exclusion of employees due to the criteria mentioned above, 3070 individuals were invited to the study. Of these, 215 were managers who were invited to respond to a managerial survey. Table 1 shows the distribution of

the sampled participants within each organisation, office building and unit. A unit is a group of at least three people who have the same manager. The description below concerns the total sample of the project, that is, before exclusion of cases who had fulfilled the exclusion criteria for each study.

Table 1. Descriptive statistics of the data collected.

Organisation	*1*	*2*	*3*	*4*	*5*	*Total individuals*
Individuals in:						
Cell offices	440	113	1	1	21	576
Shared rooms	230	7	0	0	7	244
Small OPO	369	47	0	0	13	429
Medium-sized OPO	428	179	17	35	1	660
Large OPO	379	42	69	94	45	629
Flex-offices	77	2	61	6	0	146
Office type missing	302	13	61	8	2	386
Total individuals invited/organisation	**2225**	**403**	**209**	**144**	**89**	**3070**
Buildings	15	2	1	1	2	21
Units*	115	29	15	9	7	175
Floors	36	8	4	3	3	54
Age of individuals years (SD)	47.8 (10.7)	44.8 (10.5)	46.6 (10.0)	47.3 (9.6)	45.0 (10.4)	47.2 (10.6)
Gender (Female)	68%	50%	39%	38%	20%	61%
Educational level (High)	80%	64%	53%	81%	49%	75%

*A unit constitutes of at least 3 people who have the same manager. OPO = Open-plan offices

As shown in Table 1, 89 employees within one organisation were invited to participate. This amount was smaller than the 100 people that were a criterion for being included. The reason behind this was that a larger unit working in this building decided to withdraw their participation due to increase in workload after data collection had begun in the rest of the units.

The process of data collection

Immediately after the information meeting, participants were asked to conduct the cognitive tests in a quiet condition from their own desk. Those who did not attend the information meeting were given the opportunity to be briefed through a video clip containing the same information that was given at the information meeting. These individuals were then asked to conduct the tests

from a quiet room or meeting room and make sure to not be disturbed while they conducted the tests in the quiet condition. After each of the two tests, the employees were asked to respond to two questions regarding whether they had been interrupted and disturbed while they conducted the tests. They were also asked where they conducted each condition of the tests. Employees who did not conduct the tests immediately after the information meeting and who did not conduct the tests in a cell office or in a quiet room, were excluded given that silence could not have been guaranteed.

Later the same day as the information meeting or the day after, the links to the e-survey were sent out. For the e-survey and the tests, reminders were sent out twice per week. After a couple of weeks, a physical reminder was sent by regular mail.

General description of the measures

As mentioned above the studies of this thesis are based on data gathered in the project "Open-plan office, leadership and health". Below data gathered in the project is presented together with a description of which data was used in which study in the present thesis. A more detailed description is given of the variables that were included in the studies of this thesis.

Cognitive data

Two cognitive tests, Immediate Free Recall (IFR) (Nilsson et al., 1997) and the Attention network test (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002) were implemented in a survey platform for the purpose of the project. These two tests were administered in two different conditions: the quiet baseline conditions (also called T1) and in normal working conditions (also called T2). In the quiet baseline conditions all employees were asked to switch off their phones, e-mail clients, and not to talk to each other during the time it took to finish the tests. By means of that and by letting people in the whole office or at each floor start the tests at the same time, a quiet condition could be created. In the normal working conditions the employees were asked to allow their telephone and e-mail client to be on, but to avoid answering any calls or e-mails. From the day following completing the tests in the quiet condition, each employee could conduct the tests in normal working conditions. In order to not contaminate the data with systematic bias or increased variance arising from diurnal variation in the dependent variables, both the tests at T1 and T2 were conducted in the morning. The tests at T1 were conducted between 8.00 AM to 12.00 AM. T2 was further restricted to 09.30 AM to 11.30 AM in order to make sure that the activity in the office had started and that people had not gone out for lunch. The participants could conduct the tests in

normal working conditions during a one-month period after they had conducted the tests in quiet baseline conditions. In order to be able to control for any learning effects, one office, which contained different office types, was chosen. The employees working in this office, also referred to as the control group, conducted both the first and second condition in quiet conditions. After the data had been gathered, possible quality issues with the implementation of the ANT module were detected, which prevented further use of this module for the purpose of the present thesis.

Study II is based on data gathered with the test IFR (Nilsson et al., 1997). IFR consisted of four consecutive trials. In each trial, the participant was shown a list of 12 words, these words were shown one after the other and remained on the screen for 2 seconds. After the 12th word had been shown, each respondent had 45 seconds to type down as many words as he/she remembered. After these 45 seconds, a 10-second break followed before a list of 12 new words was shown and the respondent once again had 45 seconds to type down as many words as they remembered. In total, four lists of 12 words were shown in each condition.

As mentioned, IFR was administered in two conditions: T1 and T2. After each condition, the respondents could indicate whether they had been disturbed during the test by answering the question: "Were you disturbed during the test so that you looked away when the words were presented?" This variable was used as an indicator of distraction at T1.

E-surveys

Two survey were created: one addressing the employees without personnel responsibility and another addressing managers with personnel responsibility. Before putting together the surveys, five semi-structured focus group interviews, with between eight to twelve people in each, were conducted in order to increase our understanding of what types of questions should be included in the survey. People invited to these focus groups were both managers and safety officers from two of the organisations that had already responded that they would like to participate in the project. The e-survey addressing employees contained in total 336 individual items. Some of the scales used established scales measuring different types of work outcomes, for example, the Maslach Burnout Inventory-General Survey (MBI-GS) (Schutte et al., 2000), and the cognitive stress scale from the Swedish version of the Copenhagen Psychosocial Questionnaire (COPSOQ) (Kristensen et al., 2005). However, many other items were constructed just for the purpose of the overall project "Open-plan office, leadership and health" rather than for the purpose of the studies of the present thesis. The managers were addressed by a separate e-

survey, which contained 48 items. A full list of the areas covered in the surveys is presented in Table 2. Table 2 also shows which measures were included in which study.

Table 2. Areas covered in the employee and managerial survey

Employee survey	
Office types[1,2,3] (Bodin Danielsson & Bodin, 2008)	
Leadership	Control
	Praise
	Knowledge about work environment etc.
Individual differences	
	Big Five (measured by IPIP)[3] (Goldberg et al., 2006)
	Stimulus screening ability[3] (Mehrabian, 1976)
	Need for privacy
	Coping with distraction
Psychosocial work environment	
	Conflict between colleagues
	DCQ (Sanne, Torp, Mykletun, & Dahl, 2005; Theorell et al., 1988)
	Workplace conduct rules
	Job insecurity (Hellgren, Sverke, & Isaksson, 1999)
	Information flow within the organisation
	Work Composition
	Participation in change process
	Productivity
	Maslach Burnout Inventory (MBI) (Schutte et al., 2000)
	• Exhaustion[1]
	• Depersonalization[1]
	• Professional efficiency[1, 3]
	Job satisfaction[3] (Hellgren et al., 1997)
	Distraction[1, 3]
	Sickness absence & presence (Leineweber, Westerlund, Hagberg, Svedberg, & Alexanderson, 2012)
	Health symptoms
	Cognitive stress[1] in COPSOQ (Kristensen et al., 2005)
	General health[1] (Leineweber et al., 2013)
Physical work environment	
	Temperature
	Ventilation
	Noise

	Employee density	
	Amount of back-up rooms	
	Preference towards different office types	
Managerial survey		
	Knowledge about work environment	
	Communication	
	Employee health awareness	
	Mandate for change	
	Productivity of employee	
	Preference for different office types	

1 = measures included in study I; 2 = measures included in study II; 3 = measures included in study III

Both the e-surveys and the cognitive tests were accessed through a link that the employees received by e-mail. By following the links the employees could initiate the tests or complete the e-survey.

Floor plans

Floor plans were also requested from the organisations in order to later locate each employee on the plan according to the location of their desk. This information was used for all three studies. For those respondents whose desk's position in the office could not be mapped, the respondent's own answers in the survey were used to assess office type.

Register data

Register data regarding absenteeism for each employee was gathered from four organisations that participated in the study. These data were gathered directly from the organisations' HR-departments for the period 1st October 2011–30th September 2012. These data were not used in the studies included in this thesis.

Study I – Concentration requirements modify the effect of office type on indicators of health and performance

Background

In many cases it is argued that office type has an impact on employee health and performance. Previous studies have shown that in open-plan offices health is negatively affected compared with cell offices. These findings might be more or less relevant depending on the concentration demands of the job. With

a few exceptions (Bodin Danielsson & Bodin, 2008; Bodin Danielsson et al., 2014), research has focused less on differentiating office environments. Hence, the focus in Study I was to investigate the main effect of office type on employee health and performance and also to investigate whether different office types have different effects on employee health and performance, depending on how much concentration the work tasks require.

Aim

The aim of Study I was to investigate the main effect of office type, as well as the interaction effect between office type and the concentration that the job requires on indicators of both health and performance. The hypotheses were: 1a) office types that accommodate more people are associated with more health and performance problems, 1b) employees in flex offices report fewer health and performance problems than those in open-plan office environments, and 2) that there is an interaction effect between office type and the need for concentration that the job requires. I hypothesize that having a job that requires a higher level of concentration, in contrast to having a job demanding a low/medium level of concentration, is associated with more health and performance problems in open-plan offices but not in: 2a) cell offices and 2b) flex offices.

Method

For the purpose of Study I, data from the employee survey were used together with the information recorded on the floor plans.

Sample

After removal of invalid cases—such as newly employed employees or those who spent less than 25% of their working time at their desk—2087 professionals or higher-grade clerks, from 175 units in 5 different organisations remained from the original sample, of which 1445 (69%) responded to the survey. The effective sample size was 1241, corresponding to employees who had no missing answers concerning the variables included in the analyses.

Measures

The outcome variables in this study were: distraction, the cognitive stress scale in the Copenhagen psychosocial questionnaire (COPSOQ) (Kristensen et al., 2005), the Maslach Burnout Inventory-General Survey (MBI-GS) (Schutte et al., 2000) including the exhaustion, depersonalization and professional efficiency subscales, and finally, a general measure of health (Ahola et al., 2008; Idler & Benyamini, 1997; Manderbacka, Kåreholt, Martikainen, & Lundberg, 2003).

The independent variables were office type and need for concentration the job requires. Office designs were categorised into the following office types: individual office rooms, shared rooms, small open-plan offices, medium-sized open-plan offices, large open-plan offices, and flex offices (Bodin Danielsson & Bodin, 2008).

Need for concentration was assessed by one question: "To what extent do you have individual tasks that require concentration". The 5-point Likert response scale went from to "low extent" (1) to "large extent" (5). Due to the highly skewed distribution towards high values, responses of 1–4 were categorized as low/moderate and responses of 5 were categorized as high need for concentration.

Analysis

The main analysis was conducted by a 2 x 6 MANCOVA where the main effect of office type, as well as the interaction effect between office type and need for concentration, on the outcomes were investigated. Age, educational level, sex, and labour market sector were entered as covariates. Contrast analyses were also part of the analyses which tested our hypotheses regarding whether or not cell offices differed from open-plan offices regardless of size, and if flex offices differed from open-plan offices regardless of size. Finally, contrast analyses were conducted to test for differences depending on the need for concentration the job requires within each office type.

Findings

There was a significant main effect of office type on two of the six investigated outcomes: distraction and cognitive stress. Respondents working in cell offices reported significantly less distraction than those working in any other office type. Respondents in flex offices reported less distraction than those working in open-plan offices regardless of size. For cognitive stress, employees in cell offices reported significantly lower stress as compared to employees in small open-plan offices, medium-sized open-plan offices, large open-plan offices, and flex offices. Respondents in flex offices did not report less cognitive stress as our hypothesis 1b had suggested. There seemed to be a trend illustrating a dose-response relationship between the size of the open-plan office and respondents' perception of distraction and cognitive stress. However, these trends were not significant for either distraction or cognitive stress.

The analysis investigating the interaction effect between office type and concentration need revealed that the interaction effect was significantly related to distraction and cognitive stress. The level of distraction did not differ significantly between low/moderate and high need for concentration groups in cell

offices, while it was significantly higher for employees with high need for concentration in all other office types. For cognitive stress, the level within each group did not differ significantly in cell offices and flex offices, while it was significantly higher in all other office types. These results supported hypothesis 2a and, in part, hypothesis 2b.

The findings indicate that working in more dense office types is associated with both self-rated distraction and cognitive stress. Concentration demands of the job seem also to play a role, in such a way that having jobs that demand more concentration is associated with more problems in all office types except for cell offices. In general, working in flex offices seem to be associated with fewer problems than working in open-plan office environments but are associated with more problems when compared to cell offices.

Study II – The association between office design and performance on demanding cognitive tasks

Background

Study I showed that employees rate distraction and cognitive stress higher in open-plan offices compared with employees in cell offices. However, Study I did not show any effect on the overall performance related measure, professional efficiency. This might have been due to the fact that employees in more busy office types have developed behavioural strategies, such as coming early to the office or conducing concentration-demanding tasks when the office environment is less busy. The purpose of this study was therefore to investigate how performance on a demanding task is affected in normal working conditions as compared to a quiet baseline conditions across different office types.

Aim

Given that Study I indicated that levels of distraction and cognitive stress are affected differently depending on the interaction between office type and the concentration demands of the job, Study II aimed to investigate whether different office types differ in how employee performance is affected during normal working conditions. For the purpose of this study, a repeated within and between subject design was used, testing the drop in performance on a memory test in normal working conditions (T2) compared to a quiet baseline condition (T1) in different office types (cell offices, small open-plan offices, medium-sized open-plan offices and large open-plan offices) (Bodin Danielsson & Bodin, 2008). In order to differentiate any learning effect from the effect of being in a normal (non-quiet) work situation, employees in one

office conducted both T1 and T2 in quiet settings. These employees are referred to as the controls.

The hypotheses were: 1) performance in all office types, except in the control group, would drop in T2 as compared to T1, that 2) individuals working in cell offices would have the smallest drop in performance during the normal working condition, as compared to those working in open-plan offices, and 3) the drop in performance would increase with the size of the office; that is the larger the open-plan office, the higher drop in performance. This hypothesis was tested: 3i) for small open-plan offices in comparison to large open-plan office environments, 3ii) by comparing small and medium-sized open-plan offices, and 3iii) by comparing medium-sized open-plan offices and large open-plan offices. These analyses were considered for: a) Total score, b) Secondary memory, and c) Primary memory.

Method

Sample

Out of 2110 employees from the four organisations that were invited to this study, 833 met the exclusion criteria of: having disabilities that affected their performance on the test, or having an individual office room while all of their colleagues were working in open-plan offices, and were excluded. This was done in order to reduce the risk of selection effects resulting from individuals having been given individual office rooms due to special health-related needs. During the initial stages of the data collection, there were some technical problems with the testing platform, which led to exclusion of 246 cases. Unusual response patterns indicating cheating also led to exclusion (n=24). 296 employees did not participate at all and 175 employees conducted only T1. Also outliers were removed (n=9). The effective sample size was 527 cases.

Measures

Immediate Free Recall (IFR) (Unsworth, Spillers, & Brewer, 2010) was used for the purpose of this study. Based on the correct number of recalled words a Total score was calculated. In addition, Primary and Secondary memory scores were calculated according to Tulving and Colotla (1970) by considering the position of the word when they were presented and recalled. These three variables together with the response concerning whether the respondent were disturbed during the test at T2, were used in the analyses of this study.

Office type, including controls, was used as the independent variable.

Analysis

The main analyses conducted were a two-way repeated ANCOVA on Total score and a two-way repeated MANCOVA for Primary and Secondary memory. Contrast analyses were conducted to test our hypotheses. Pairwise comparisons with Bonferroni adjustment were conducted to investigate differences between the marginal means at T1 for the significant outcomes. Covariates used in the model were educational level, age, labour market sector, sex and distraction at T1.

Findings

The pairwise comparisons with Bonferroni adjustment conducted for Total score and Secondary memory were not significant, indicating no differences in T1 between the different office types.

The two-way repeated ANCOVA was significant for Total score and the two-way repeated MANCOVA was significant for Secondary memory. For both Total score and Secondary memory the following hypotheses were significant: 1, 3i, and 3iii. The findings suggest that respondents in all office types in contrast to controls, who conducted both T1 and T2 during quiet conditions, have a drop in performance at T2 in comparison to T1. Support was also found for the assumption that employees in open-plan offices drop in performance in relation to the size of the office. However, the difference in drop in performance between small and medium-sized open-plan offices was not significant. The hypotheses were contradicted by the lack of significant difference in drop in performance between cell offices and open-plan office environments. In fact, respondents working in cell offices had as high a drop in performance as respondents in large open-plan office environments. This finding was quite unexpected given that respondents in cell offices usually rate being less distracted than those working in open-plan office environments and descriptive statistics regarding respondents' ratings of how distracted they were during T2 reveal that respondents in cell offices reported being distracted to a smaller extent than respondents in open-plan office environments.

In summary, these findings suggest that the drop in performance is higher in larger open-plan offices as compared to smaller. Although individuals in cell offices report being less distracted, employees working in cell offices have as high drop in performance as do employees working in large open-plan office environments.

Study III – Do office design and individual differences in personality matter for indicators of job performance?

Background

As shown in Study I, concentration demands of the job moderate the main effect of office type on employee health and performance. Another moderator that may affect the relation between office type and employees performance is individual differences in personality. Although the importance of the interaction effects between office type and individual differences in personality has been suggested (Oldham et al., 1995), there are no strong empirical studies investigating this effect. Therefore this study focused on the interaction effect between office type and individual differences in personality on performance outcomes.

Aim

The aim of Study III was to investigate the interaction effect between office type and individual differences, as measured by Big Five personality traits and stimulus screening ability, on outcomes related to job performance. Given that there are neither strong empirical findings nor strong theories regarding the interaction effect between office type and individual differences in personality, explorative research questions were proposed instead of hypotheses. Study III focused less on the main effect of office type on performance outcomes given that the main effect of office type on two out of three outcomes (distraction and professional efficacy) already had been addressed in study I.

Method

Sample

This study was based on the same original sample as study I. The effective sample size in the main analyses in Study III varied between 1133 and 1171 cases depending on missing answers in the inventories measuring Big Five personality traits and stimulus screening ability.

Measures

As in previous articles, distraction and professional efficiency (Schutte et al., 2000) were included as measures. These two measures were complemented by a measure of job satisfaction (Eggerth, 2015; Judge, Thoresen, Bono, & Patton, 2001), given that job satisfaction has been shown to be an important factor for employee performance (Hellgren et al., 1997).

The personality traits included in the analyses were stimuli screening ability, measured by 10 items about the ability to effectively reduce overstimulation by focusing only on relevant information with a 7 point rating scale (1=strongly disagree, 7=strongly agree) (Mehrabian, 1976) and the Big Five traits: Agreeableness, Extroversion, Emotional stability, Imagination (also called openness to experience), and Conscientiousness measured with the Swedish version of the 50 items International Personality Item Pool (IPIP) with a 5-point rating scale (1=very inaccurate, 5=very accurate) (Goldberg et al., 2006). All traits were dichotomized so that the highest one-third of the sample was compared with the lowest one-third of the sample. This dichotomization was motivated based on the suggestion that the relationship between personality traits and job performance might not be linear but accentuated for people who have more extreme personality (Barrick & Mount, 1991).

The office types included in this study were cell office, shared rooms, small open-plan office, medium-sized open-plan office, large open-plan office and flex office (Bodin Danielsson & Bodin, 2008).

Analysis

Six separate 2 x 6 between-subject multivariate analysis of covariance (MANCOVA)—one for each individual difference measure—were performed on the three outcomes mentioned above. For each MANCOVA analysis, the explanatory variables were office type and one of the six individual differences traits.

Post hoc ANCOVAs were carried out to reveal which outcome variables contributed to the results of the MANCOVAs. The covariates included in the analyses were age, labour market sector, sex, and educational level.

Findings

Out of the six separate MANCOVAs, only one was significant, suggesting an interaction effect between office type and agreeableness. The analyses revealed that the outcome variables that varied depending on the joint effect of office type and agreeableness were distraction and job satisfaction.

In medium-sized open-plan offices, large open-plan offices and flex offices, distraction was significantly higher for employees who were high in agreeableness compared to employees low in agreeableness. Concerning job satisfaction, the analyses indicated that job satisfaction was significantly higher only for more agreeable employees in comparison to less agreeable employees working in small open-plan offices and medium-sized open-plan offices. However, being more agreeable, compared to being less agreeable, and working in flex offices was associated with lower job satisfaction.

A plausible explanation for these results is related to the opportunities people have to become familiar with each other's needs. In office types that house more people or in flex offices where people rotate, highly agreeable people might not feel comfortable enough to express their needs. Therefore, others might not be as acquainted to their needs, hence exposing them to more unwanted stimuli.

Discussion

The scientific literature has investigated the effects of spatial office design and flexible ways of working—that is providing the option of working from home and choose desk at the office—on employees. The purpose of the present thesis was to further investigate the main effect of office type, and also explore whether individual differences in personality or concentration demands of the job influence the association of office type with employee health and performance. Below I will discuss the contribution that this thesis has made to the scientific literature, discuss the strengths and weaknesses of the studies included in this thesis, and suggest some future avenues for research before making some concluding remarks.

The main effect of office type

The first aim of this thesis was to investigate the main effect of office type on indicators of both health and performance. The results reported in the present thesis confirmed that, in general, there is a higher prevalence of health and performance problems in open-plan offices compared to cell and flex offices.

The papers show that employees in cell offices report both less distraction and less cognitive stress compared to employees in other office types. These results are in line with previous research which indicates disadvantages of open-plan offices in comparison to cell offices when it comes to the common cold (Jaakkola & Heinonen, 1995), sickness absence (Pejtersen et al., 2011) and distraction (Kaarlela-Tuomaala et al., 2009). Several mechanisms, such as increased noise, reduced autonomy and higher exposure to viruses, have been suggested to cause the negative effects of open-plan offices as compared to cell offices (De Croon et al., 2005; Pejtersen et al., 2011). These mechanisms, and not only the association of office type with health and performance outcomes, should be further investigated in future field studies in order to improve the understanding of how organisations with open-plan office environments can decrease the problems associated with these environments. For example, if viruses cause increased sickness absence in open-plan offices as compared to cell offices, knowledge about whether the infections occur as a result of ventilation or direct contact between people could be helpful for implementing effective countermeasures.

The present thesis also showed relatively positive effects of flex offices in comparison to open-plan office environments, since employees in flex offices reported lower level of distraction than employees in open-plan office environments. This finding is in line with the study of Bodin Danielsson and Bodin (2008), which showed that employees working in flex offices as compared to those working in open-plan offices rated their health and performance more positively, but contradicted the findings of Bodin Danielsson et al. (2014) who showed that men working in flex offices reported more short-term sickness absence. How can these contradicting results concerning flex offices be understood? One way to explain these contradicting results is by looking at the methods used in these studies. The data in the current thesis and the data used in Bodin Danielsson and Bodin (2008) were cross-sectional while Bodin Danielsson et al. (2014) studied the prospective association between office types and sickness absence by using two waves (year 2010 and 2012) of the Swedish Longitudinal Occupational Survey of Health (SLOSH) with the inclusion criteria for the sample that the participants should have not changed job between 2010 and 2012. One can assume that people who feel that their health is negatively affected by the office environment and have opportunities to change their job choose to do that. Given that Bodin Danielsson et al. (2014) only included people who had not changed job between 2010 and 2012, their sample may include a higher proportion of locked-in employees (Aronsson & Göransson, 1999). In comparison to cell offices, the less predictable flexible ways of working in flex offices may be more demanding for these individuals, something that could have moderated the effect on sickness absence. This argumentation is based on several assumptions but shows the importance for workplace environment researchers to develop theories and empirically test these, so that a better understanding can be developed concerning what causes the effect of office type on health outcomes.

The present thesis also indicates that cell offices could be advantageous compared to flex offices in terms of distraction and cognitive stress, something which contradicts previous findings showing that flex offices have a similar effect on employees' health and performance as do cell offices (Bodin Danielsson & Bodin, 2008). The advantage of a cell office in comparison to a flex office may be related to individuals' increased control of the physical environment. Even if people working in flex offices have the opportunity to choose where they work, the opportunity or the demand of repeatedly changing location throughout the working day can in itself be demanding. Constantly shifting may prevent employees from perceiving their work environment as predictable and require more adapting to in comparison to people who have a designated desk or room. As individuals adjust to their new environment, this may have unfavourable effects in the form of stress reactions, referred to as the cost of adaptation process (Glass, Singer, & Friedman, 1969).

This cost may explain why flex offices, which provide choices regarding where to work, are worse than cell offices and no better than open-plan offices in relation to cognitive stress.

The present thesis further investigated the immediate effect of office type on performance. In line with expectations, it was shown that larger open-plan offices in comparison to smaller open-plan offices were associated with a larger drop in performance as indicated by immediate free recall. An unexpected finding was that individuals working in cell offices had as large a drop in performance as did those working in large open-plan office environments. Unsurprisingly, laboratory studies have shown the benefit of quiet conditions as compared to more noisy conditions when it comes to solving complex tasks (Jahncke et al., 2011; Perham et al., 2007), which raises the question of whether individuals working in cell offices do in fact exert control over the physical office environment and manage to create a quiet atmosphere. Adaptation to irrelevant stimuli may also explain this surprising finding. That is, changes in perception of irrelevant stimuli may occur as a way to cope with problems in less well functioning office types (Sundstrom, 1986). The adaptation hypothesis would be applicable if one considers that in an open-plan office environment it is easier to cope with irrelevant stimuli when the office environment accommodates fewer people rather than many. On the other hand, adaptation may not occur for employees in cell offices if one assumes a generally low level of constant presence of irrelevant stimuli, causing these individuals have a lower threshold for which stimuli are distracting or not. The adequacy of this interpretation of the results of Study II needs to be investigated, but the fact that Study II also showed that employees in cell offices reported fewer distractions during normal working conditions than individuals in all other office types indicate that this hypothesis might be true to some extent.

It is also worth mentioning that out of the three measures that were calculated based on the employees' performance on IFR, the most demanding measure, Secondary memory performance, was significant, while Primary memory performance, which is less demanding (see Unsworth et al., 2010), was not. The stronger effect of office type on drop in performance on Secondary memory performance confirms the overall hypothesis that performance on concentration demanding tasks is more easily hampered than performance on simple tasks. This finding brings attention to the possibility that office type might interact with concentration demands of the job in how it affects employees. This interaction effect together with the interaction effect between office type and personality on health and performance outcomes are discussed below.

Moderators of the effects of office type

Apart from investigating the main effects of office type, the present thesis also investigated to what extent concentration demands of the job (aim 2a) and individual differences in personality (aim 2b) moderate this main effect.

Concentration-demanding tasks

The present thesis showed that open-plan offices were associated with increased distraction and cognitive stress when employees had a high rather than low need for concentration. In flex offices, when employees reported having more need for concentration they also reported higher levels of distraction and cognitive stress, but only the distraction measure differed significantly between the low and high need of concentration group. In cell offices, regardless of the need for concentration, the employees reported the lowest levels of distraction and cognitive stress, indicating that high need for concentration led to fewer problems in cell offices. Furthermore, although flex offices seem to confer some benefits as compared to open-plan office environments without flexible seating, flex offices are much more similar to open-plan office environments than to cell offices when it comes to how they affect employees. These results are in line with theoretical frameworks that suggest that high levels of arousal hamper completion of complex tasks (Anderson et al., 1989; Duffy, 1957; Yerkes & Dodson, 1908) and previous findings that people with long tenure and high job complexity report lower levels of positive outcomes in high density offices as compared to low density offices (Fried et al., 2001). They are also in line with other findings suggesting that managers and professionals reported more problems after moving to an open-plan office from cell offices, while clerical employees with less advanced work tasks reported fewer problems (Zalesny & Farace, 1987). Hence, previous studies together with the present thesis indicate that employees with complex work tasks report more beneficial effects in cell offices rather than employees with complex tasks who work in open-plan or flex offices. Several reasons could explain why findings indicate an interaction effect between office type and complex tasks. The arousal hypothesis has been suggested above, and also theories concerning stress (Berkun, 2000; Lazarus, 1966) and cognitive load or mental effort (Lavie et al., 2004) were suggested in the introduction. However, which mechanism or mechanisms cause the effect is quite unknown and needs to be investigated in future studies.

Although both distraction and cognitive stress outcomes were significantly related to office type in Study I, none of the MBI-GS subscales nor general health were significant for the main effect of office type or the interaction effect between office type and concentration-demanding task. A possible reason might be that the health outcomes used are approximately ordered in a

causal chain. That is the association between office type and cognitive stress may be stronger than the association between office type and burnout, which in turn would be stronger than the association between office type and general health. Therefore, even if prolonged exposure to cognitive stress may in the long run lead to a worsened general health status, the association between office type and general health should be weaker. Thus, this study may have lacked the power required to find significant associations with exhaustion, depersonalization and general health. In fact, previous studies, which have found associations between office type and sickness absence (Bodin Danielsson et al., 2014; Pejtersen et al., 2011) have had at least a 30% larger sample size. Similarly, relatively low power may also explain why a significant association with distraction and not professional efficiency was found. Another reason why professional efficacy remained insignificant may be that coping strategies can attenuate the effect of office type. For example, if employees in open-plan offices are constantly distracted, they might adapt what they are doing to how busy the office environment is, hence choosing to conduct less demanding tasks when the level of irrelevant stimuli in the environment is high. By doing so, the general efficacy may not decrease even if the perception of distraction is high.

Individual differences in personality

Apart from differences in the concentration demands of the job, the present thesis also investigated the interaction effect between office type and personality as measured by the Big Five traits: extroversion, agreeableness, conscientiousness, emotional stability and imagination (Goldberg et al., 2006) and stimulus screening ability (Mehrabian, 1976). Agreeableness was the only trait that together with office type contributed to how much employees were distracted and satisfied with their jobs. Highly agreeable people are described as trusting, altruistic, cooperative, modest and tender minded (Cooper, 2010). Because of their predisposition to avoid conflicts, these individuals might have difficulties in safeguarding their own needs. The ability to express one's own needs in order to create a sufficiently good work environment might be more important when the office type is open and when the ways of working are flexible as compared to working in cell office in which employees to a much higher degree are able to control the physical work environment themselves. This interaction can therefore explain why the trait agreeableness matters in open-plan offices and flex offices while it does not in cell offices.

None of the other individual differences measures interacted with office type on the outcome variables. This was quite unexpected given that previous studies have shown some effects of individual differences in personality by indicating that higher stimulus screening ability leads to fewer problems in more open and busy environments (Mehrabian, 1977; Oldham, 1988). The rather

small effect size in the present thesis concerning personality could be due to different causal pathways having opposing effects on the outcomes. For example, people high on the trait extroversion who enjoy the company of others (Cooper, 2010) may be motivated to work in open-plan offices given that open-plan offices allow them to constantly interact with colleagues. But extroverted people working in open-plan offices might also be over-stimulated and focus less on tasks that do not demand interaction, hence lowering their performance in general. In the same vein, neurotic people may find comfort in cell offices given the smaller amounts of irrelevant stimuli in the environment; however, in open-plan offices these individuals may find comfort and support in having others around them. These possible contradicting routes may cancel the overall interaction effect between office type and each of these traits. Therefore, if contradicting routes exist, it would suggest that it is not the overall trait that should be in focus, but rather specific behaviours or cognitions such as being motivated by or finding support in the company of others.

Effect sizes

One way to investigate the relevance of office type and the moderators—concentration demands of the job and personality—that this thesis has focused upon is to consider the effect sizes. A large effect size suggests that the variables explain a considerable part of the variance in the outcomes while a small effect size suggests that the variables explains a minor part (Cohen, 1988).

In Study I, it was found that the effect size was larger for the main effect of office type compared to both the main effect of concentration demands of the job and to the interaction effect between office type and the concentration demands of the job on health and performance outcomes. In Study III, it was found that office type alone had a larger effect size than the interaction effect between office type and personality. Office type had also a larger effect size than the main effect size of personality, with the exception of emotional stability and stimulus screening ability. This indicates that having difficulties handling emotions or not being able to screen away irrelevant stimuli is associated with more problems regardless of office type. However, office type is a more important variable for indicators of performance than are the traits extroversion, agreeableness, conscientious or imagination. Hence, although the lack of research investigating the interaction effect between office type and individual differences and the interaction effect between office type and the concentration demands of the job urges for more scientific studies (Oldham et al., 1995), the findings of the present thesis suggest that office type alone is a much more important variable than the interaction of office type with personality and task on health and performance outcomes.

According to Cohen's rule of thumb (Cohen, 1988), the effect sizes for the significant findings concerning the main and interaction effects in Studies I–III can be considered either small or medium-sized, meaning that office type, the interaction effect between office type and individual differences in personality, and the interaction effect between office type and the concentration demands of the job have a minor effect on health and performance outcomes. However, even a small decline in employee health and performance could have a large impact on the profitability of the organisation, which gets more noticeable for organisations with a high proportion of knowledge workers. Hence, even if the effects may be considered small, their impact on the overall performance of the organisation should not be underestimated.

Methodological considerations

This thesis has some methodological limitations. Problems associated with cross-sectional data, selection bias, common method variance, representativeness and generalizability, and the validity of measures are discussed below.

Associations and not causality

Two of the studies, I and III, are based on cross-sectional self-reported data in which the employees rated their perception of their health and performance. This design has often been used to study psychosocial work and office type (Bodin Danielsson & Bodin, 2008; Kim & de Dear, 2013; Pejtersen et al., 2011; Theorell & Hasselhorn, 2005) although there are some longitudinal studies (Bodin Danielsson et al., 2014) and some investigating office redesign (Brennan et al., 2002; Kaarlela-Tuomaala et al., 2009). In order to make causal inferences two variables must be associated, the direction of the association must be established, and finally the connection between the two variables must be isolated (Bollen, 1989). In cross-sectional studies, it is not possible to fulfil all these three criteria. Although it is possible to investigate the association between two variables, in order to make conclusions about the direction of the relationship, longitudinal studies are needed unless the direction can be given on theoretical grounds.

It is also difficult to meet the criteria of isolation, given that all other potential confounding variables must be controlled for (Bollen, 1989) in order to be certain that the effects on the outcome variables do not go through other paths. For example, what defines a large open-plan office environment is that the number of employees working in the office is 25 individuals or more. But what explains the increased self-reported distractions and higher cognitive stress in large open-plan offices as compared to cell offices is probably not the number of individuals *per se* but rather the noise level, visual stimuli, actual

interruptions or a combination of all these factors. Hence, it is difficult in a field study to isolate the effect.

Selection bias

In the present thesis, as well as in most field studies where employees are not randomly selected to certain conditions, there is a risk of selection bias (Hernán, Hernández-Díaz, & Robins, 2004). For example, it is possible that people with higher cognitive capacity, hence better ability to inhibit irrelevant stimuli, are given more important roles. Higher positions may also be rewarded with cell offices rather than a desk in an open-plan office environment. Therefore this risks selecting people to different office types and the variation in health and indicators of performance might not be driven by office type *per se* but rather cognitive capacities and/or position.

This risk may appear also in the opposite direction, namely that people who have disabilities may be given cell offices due to the fact that open-plan office environments are believed to impact these employees negatively and prevent their recovery or worsen their condition. In the present project, the awareness regarding the layout of the office and the knowledge regarding where each employee were located made it possible to exclude people who worked in an office type that differed from that of their colleagues. That is, when most of the employees in an office floor were working in open-plan office environments and one or two in cell offices, the individuals in cell offices could have been given cell offices due to reasons related to certain needs. Therefore, these individuals were excluded from the analyses. Thereby, the influence of selection due to cognitive capacities or special needs among employees working in an office on the findings of study I–III was limited.

Another point of concern is that employees who have poor health might be unavailable for research purposes due to sickness absence, which may attenuate the observed associations. Furthermore, if people are satisfied with a specific office type they should be less prone to look for a new job, which in turn should result in more satisfied employees than what would be expected if office type had been randomly assigned. All in all, these possibilities related to the absence of randomization increase the risk for cross-sectional studies to show biased results. These studies might also show biased results in the opposite way, that is the effect of office type might be overestimated if people who for example are more easily distracted or cognitively stressed have difficulties finding new jobs. Nevertheless, these risks presented above are not unique for the present project but common to most field studies concerning the effect of office type on employees.

Even if it is not possible to rule out these risks, their presence or absence can be inferred by clues in the data. For example, in Study II, a surprising finding was the large drop in cognitive performance for employees in cell offices between the quiet condition and the normal working condition. Given that employees in cell offices also reported lower perceived distraction during T2, their drop might be explained by a higher sensitivity to irrelevant stimuli. Meanwhile at baseline, employees in cell offices performed as well as others, which would indicate the absence of a large selection effect due to cognitive capacities. Longitudinal studies are needed to follow employees over longer period of time in order to better control for possible selection effects.

Common method variance

Another possible bias is common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). In this project, office type was mainly assessed by objective categorization, but concentration demands of the job, individual differences in personality and the outcomes used in Study I and III were assessed by self-ratings in one and the same survey. In Study II the risk of common method bias is not present given that office type and performance were gathered by different methods.

If employees who rated their jobs as more concentration demanding also reported more distractions then the results in Study I may be biased. However, there were no differences in the outcomes between employees who reported high and low concentration in cell offices. If the impact of common-method bias had been substantial then the same effect that was seen in the other office types should have been visible also in cell offices. That is that employees reporting higher need for concentration also perceive more stress and distraction. Furthermore, for Study III, the association between the main effects of personality on the outcomes were in line with previous findings (Barrick & Mount, 1991; Hogan & Holland, 2003; Tett et al., 1991). Therefore, even if bias cannot be ruled out, there should be no major bias related to common method variance in both Studies I and III. In future studies, it is recommended that researchers either choose different methods to assess moderators and outcome variables or assess the variables with the same method but at different time point.

Representativeness and generalizability

The representativeness and generalizability of field studies have previously been discussed in the research literature (Bass & Firestone, 1980; Flanagan & Dipboye, 1980). Bass and Firestone (1980) argued that there are basically three properties or attributes that may affect the generalizability of research

results. The first one is setting aspects, which include components such as objective job description and subjective task description. The person aspects are another matter, which is related to demographic factors, abilities and personality. The third set of attributes consider response aspects, which can be divided into, cognitive-judgmental, that is based on some sort of thought processing, versus action-performance realms, that is measuring some form of behaviour. In order to assess the external validity of a research study, one must examine in what way the sample differs from the population to which one wants to generalize in regard to the three above-mentioned components. However, even if there are differences in regard to these components, generalizability can still be possible if the attributes in question do not interact with or affect the relationships among the variables of interest. Nevertheless, Flanagan and Dipboye (1980) argued that in order to empirically test the extent of generalizability, research on heterogeneous samples of settings, persons, and response styles must be conducted.

Based on the argumentation of Bass and Firestone (1980), in order to generalize the findings of Studies I–III, one must assess the similarity of the sample and the predictors used in the studies within this thesis to the employees who work in the organisation to whom we want to generalize. Furthermore, given the lack of consensus concerning the definition of office type, one needs also to have in mind the definition used in this thesis before applying the results to other contexts. That is, for example, that individual office rooms are actual rooms with four walls and a door mainly suitable for one person (Bodin Danielsson & Bodin, 2008; Sundstrom, 1986) and not a desk in open-plan office environment with high screens surrounding the desk (Duffy, 1997).

Further consideration needs to be given the generalizability of Study II due to the limitation of IFR. First of all, IFR is a short test which is completed in less than 5 minutes. Arguably, when people conduct tasks that require concentration they focus on the task for a longer period. It is possible that people can compensate for the effects of distraction by increased effort during some time, but that a negative effect on performance would have been seen after a longer time at task. Another aspect that needs to be considered is that the employees conducted the test during morning before lunch. It is possible that exposure to a constant noise level throughout a working day may lead to increased fatigue later in the day (Chen, Dai, Sun, Lin, & Juang, 2007), hence affecting their ability to concentrate. Therefore, the result from Study II should be limited to consider tasks that are conducted during the morning and demand less time to complete and may not be fully generalizable to tasks that demand longer time to complete nor performance during the afternoon.

Furthermore, IFR can be considered as a cognitively demanding task. It also demands processing of verbal information. These two points together make

the test a reasonable proxy for employees who have tasks that demand processing words. However, there are also occupational groups who at work handle visuospatial information rather than text. Given that the data used in Study II do not clarify whether the drop in performance at T2 is caused by interruptions, noise in general or by distracting verbal information from the surroundings, it is not possible to know if and to what extent the findings of Study II can be generalized to people conducting non-verbal tasks, such as visuospatial tasks.

Finally, due to logistical difficulties it was not possible to randomize the order of the conditions (quiet or normal working conditions) when IFR was administered to the employees. By including the control group, the learning effect of IFR could be assessed. Still, if there is an interaction effect between office type and learning caused by the order of the conditions then our results might be biased. The interaction effect between office type and learning might appear if the quiet condition in different office types was not similar, leading to employees in certain office types having a better opportunity to learn the test than others. A larger proportion of employees working in open-plan offices in comparison to employees working in cell offices reported being distracted during T1. However, distraction at T1 was included in the analyses as a covariate and was not significant. Nevertheless, to be more certain that the drop in performance is not affected differently depending on the order of the conditions between office types, future studies should randomize the order of the conditions.

The validity of the measures

There are some general problems concerning self-report data based on surveys. These problems concern uncertainties regarding comprehension, recall and social desirability of the respondent (Brener et al., 2003). Therefore when using different self-rated and performance-related measures as proxies of different target constructs, it is important that they have been validated. In the studies of the present thesis, different self-rated and performance related measures have been used. The subscale of Maslach burnout inventory General Survey (MBI-GS) was used to assess burnout and performance, general health was used to assess general state of health, the scale cognitive stress to assess cognitive stress symptoms and a job satisfaction scale was used to assess the degree to which people were satisfied with their jobs. These measures have been used or validated in previous studies. For example, several studies have confirmed the factorial validity of MBI-GS (Richardsen & Martinussen, 2005; Schutte et al., 2000) while general health has been related to sickness absence (Ahola et al., 2008), morbidity (Manderbacka et al., 2003) and mortality (Idler & Benyamini, 1997). The Copenhagen psychosocial questionnaire subscale

cognitive stress has in previous studies been positively associated with conflict and psychological demands and negatively associated with meaning at work and sense of coherence (Albertsen, Nielsen, & Borg, 2001). Additionally, the job satisfaction subscale used in Study III has been used in previous studies (Hellgren et al., 1997). Distraction is a commonly used measure in the scientific literature concerning office type (Brookes & Kaplan, 1972; Hedge, 1982; Roper & Juneja, 2008; Sundstrom, 1986). The scale used to measure distraction in Studies I and III has on the other hand neither been validated nor used in previous studies. Even if this is a weakness, in support of the scale the face validity of the individual items can be considered as high. For example, one question states: "How often are you for some reason disturbed so that you do not get the opportunity to fully immerse yourself in the task you have in front of you?" and another: "To what extent are you disturbed by colleagues' conversations and phone calls?". High face validity is important given that tests with high face validity tend to be more technically valid and accurate than tests with low face validity (Holden & Jackson, 1979).

Given the problems with self-rated measures, the use of the IFR test as a way to measure performance, can be considered complementary. IFR is a reasonably valid test for assessing working memory capacity in controlled environments (Unsworth et al., 2010), but in Study II the test was used as a proxy to assess performance on a demanding task rather than evaluating working memory and therefore the validity of the test as used in Study II is not verified. Given that it was not possible to be present in person when data was gathered in the normal working conditions, what caused the drop in performance in all office types remains unknown. The drop might for example be caused by interruptions that hindered the individual to perform the test rather than stimuli that interfered with working memory capacity. Nevertheless, the test relies on verbal information processing which can be assumed to be highly relevant for knowledge workers. Hence, differences in test scores between office types should have implication for employees' abilities to conduct their work, even if it is not possible to infer that differences observed in test scores among employees in different office types are due to the office types' impact on working memory capacity.

Future research

The present thesis addresses questions that only to a relatively small extent have been empirically tested previously. Concerning the concentration demands of the job, the focus of this thesis has been on work tasks that require concentration. However, in line with the above discussion, future studies should try to elaborate more on both the type of cognitive task used and also on the time of day the test is administered. Furthermore, it is also possible that

performance might vary depending on office types and how demanding the cognitive tests are. For example, there are theories suggesting that arousal caused by noise can increase performance if the task is easy (Zajonc, 1965). Therefore, open-plan office environments might be more preferable for such tasks rather than tasks that demand concentration. Another issue that the present thesis leaves for future studies is to investigate the relationship between office type and tasks that demand collaboration and communication rather than concentration.

Furthermore, during my work on this thesis another office type has increased in popularity, namely activity-based offices. Although activity-based offices can be regarded as a development of flex offices, the proponents of this office type argue that the differences are so extensive that flex offices cannot be compared to activity-based offices. Therefore future studies comparing activity-based offices with the office types present in this thesis would contribute to the field of research.

Another aspect needing to be addressed is the problem of selection bias. Given that it is not possible to randomize employees to different office types, it would be interesting if future studies could follow people for a longer period of time. By, for example, following graduating students before they begin applying for jobs and investigate what office type they begin to work in. With follow up it would also be possible to investigate if there is a higher turnover in certain office types than another.

Additionally, most of the studies conducted are conducted within the borders of single nations. There might be cultural differences that increase or decrease the effect of office type on employees' performance or health as well as in how the offices are actually planned and used. It would therefore be of interest if some international organisations could be studied to investigate possible cultural effects.

Conclusions

The present thesis has used a differentiated definition of office types when focusing on how the physical work environment impacts employees' health and performance. It showed that, although individual differences and concentration demands of the job interact with office type, office type alone is a strong predictor of the health and performance of employees.

The results from the studies in the present thesis also showed the advantage of individual office rooms in comparison to open-plan office environments when it comes to self-rated measures of performance and health. The thesis also

indicates some advantages of flex offices as compared to open-plan office environments. All these findings are in line with previous studies.

However, when it comes to more objective measures of performance, this thesis questions the benefits of cell offices. It indicates that cell offices may be associated with as high a drop in performance on demanding tasks as large open-plan office environments. Although the reason for this could not be identified, plausible explanations could be that employees do not close the door to the cell office, and hence do not create a quiet atmosphere when the task require concentration. Given that employees in cell offices in general are exposed to less irrelevant stimuli, they might not develop adequate coping strategies, hence even lower levels of irrelevant stimuli might have large effects on performance on demanding tasks.

When it comes to the effect of individual differences, this thesis showed that only the trait agreeableness interacts with office type on indicators of performance, suggesting more problems among agreeable people in contrast to less agreeable people in open-plan and flex offices.

Finally, this thesis indicates that when it comes to indicators of health and performance, small open-plan office environments are more beneficial than larger open-plan office environments. Employees reported lower distraction and cognitive stress and performed better in these environments.

In conclusion, the findings of the present thesis should be of practical benefit when organisations modify their office or move to a new location. Organisations should be aware that perceptions of distraction and employees' health are affected negatively in open-plan office environments and therefore strategies should be developed regarding how to create an office environment that deals with these challenges. The results also suggest that although employees believe that they can perform better in cell offices, it is not evident that this is the case given that their performance is affected to the same extent as employees in large open-plan office environments. Hence, although employees in cell offices might complain less, organisations should be aware of the possible lower performance that can follow if employees do not utilize the benefits that cell offices offer, namely the possibility to close the door and actively create a quiet and interruption-free work atmosphere.

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